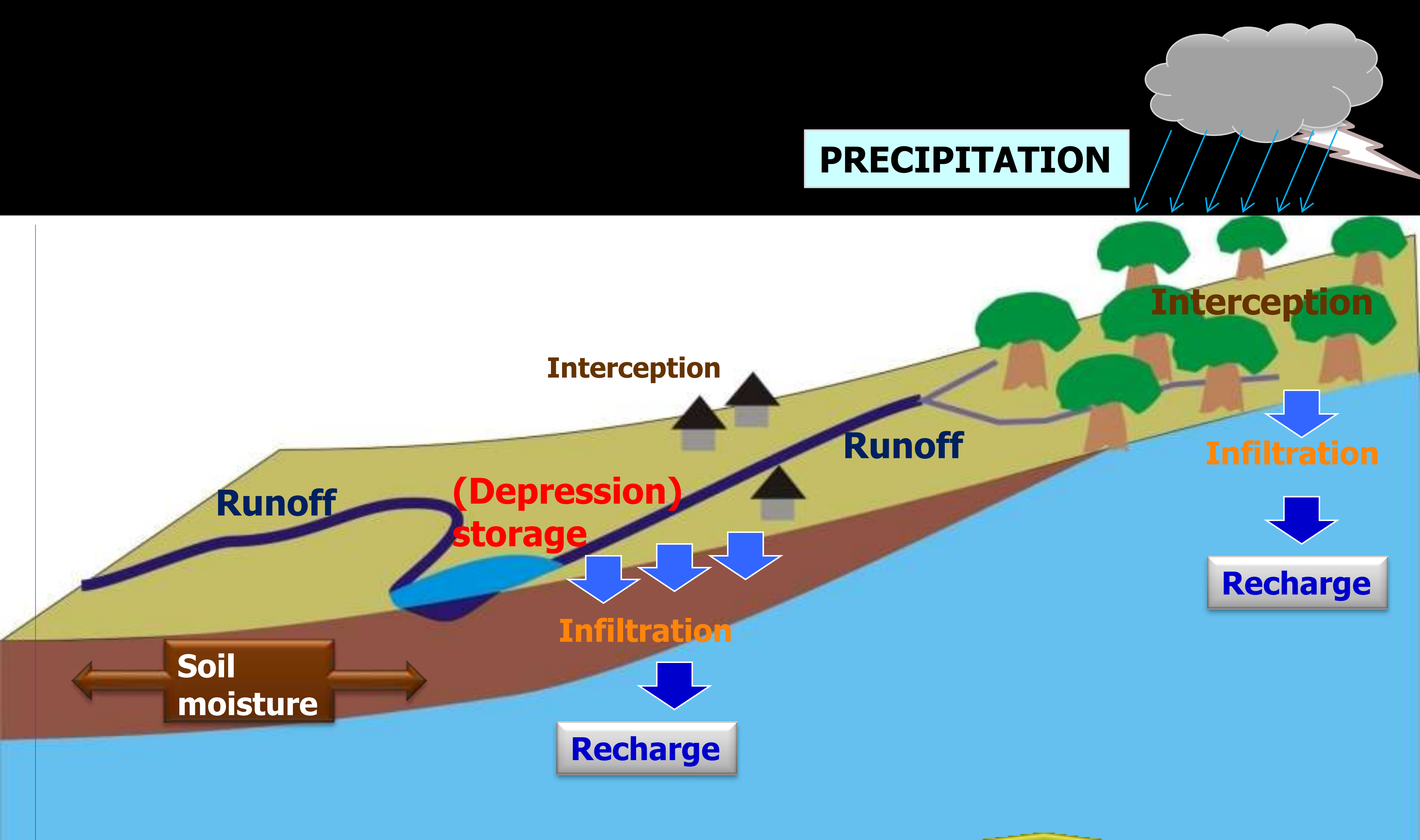
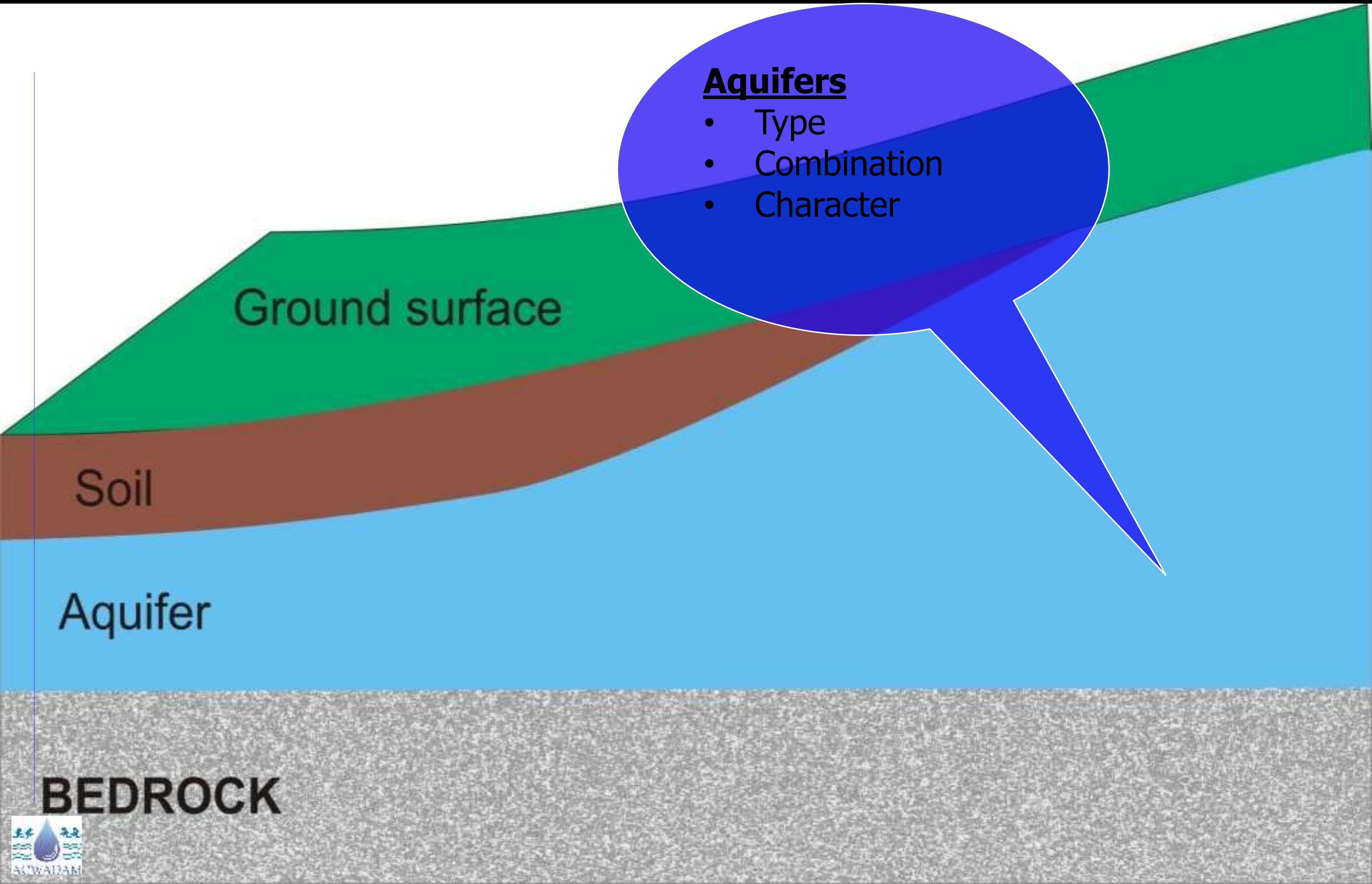
GROUNDWATER BALANCE

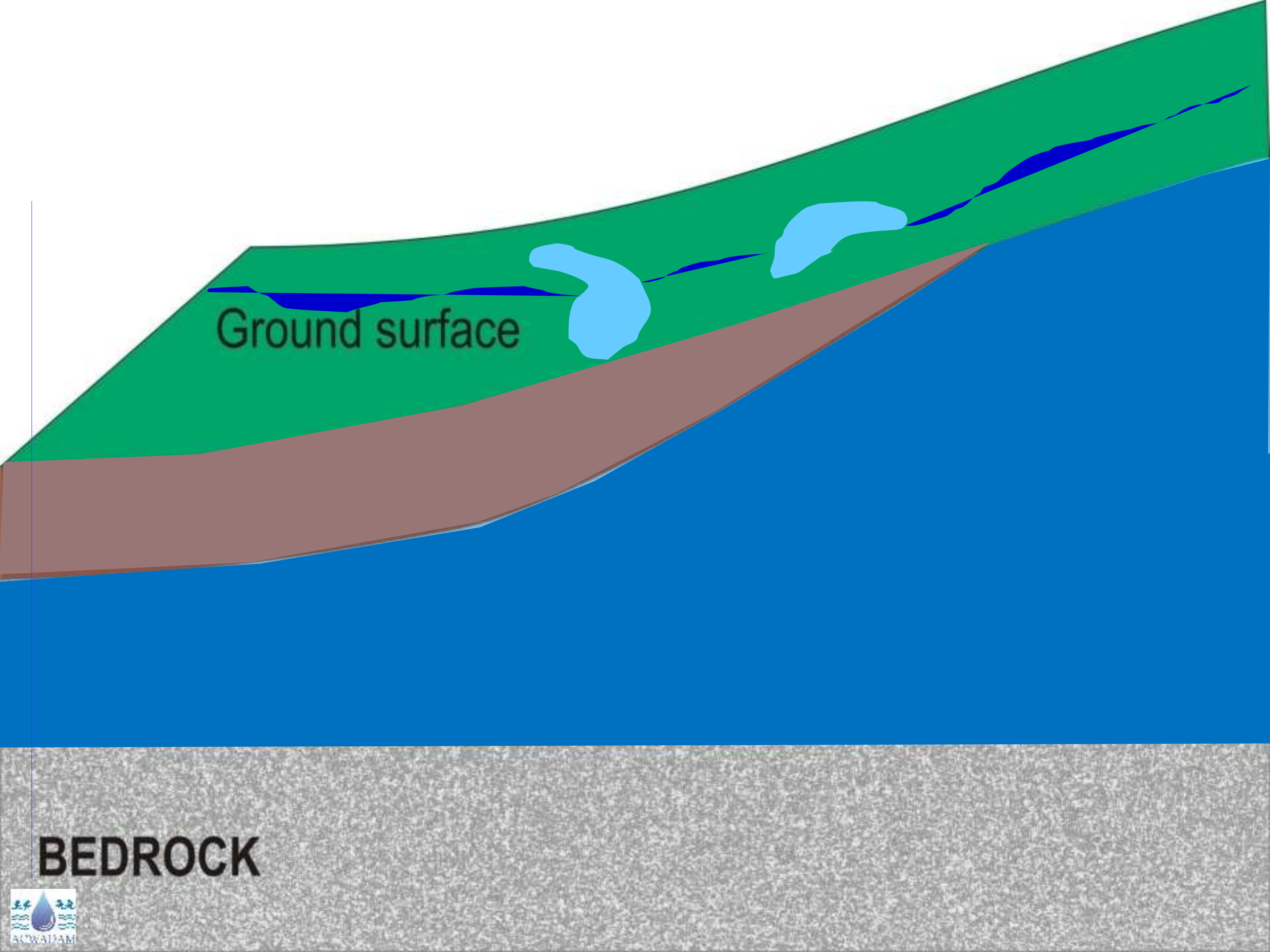
ACWADAM



Precipitation = Interception+Evaporation+Transpiration+Runoff+Infiltration

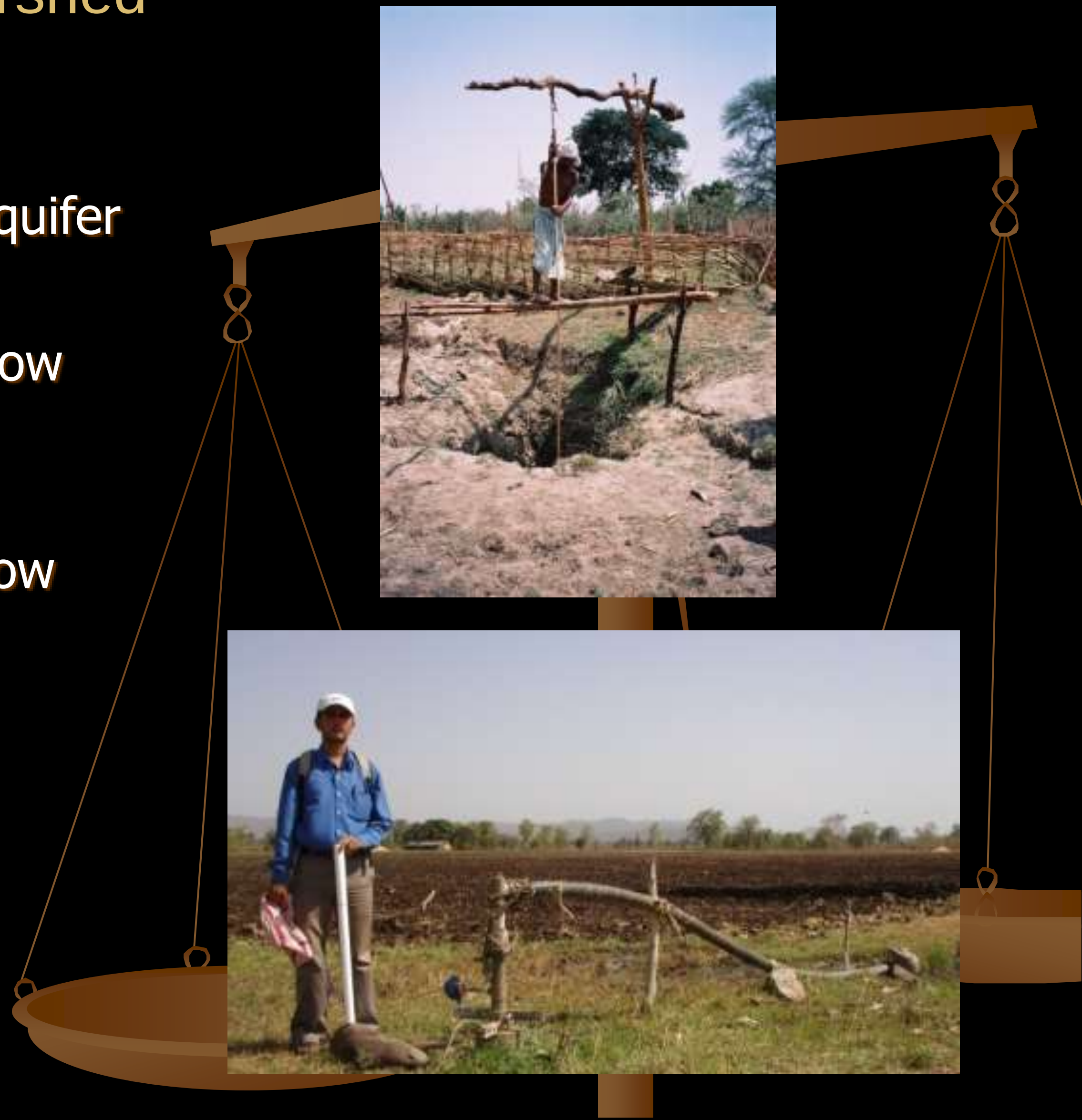
Groundwater balance…*aquifer as the unit*



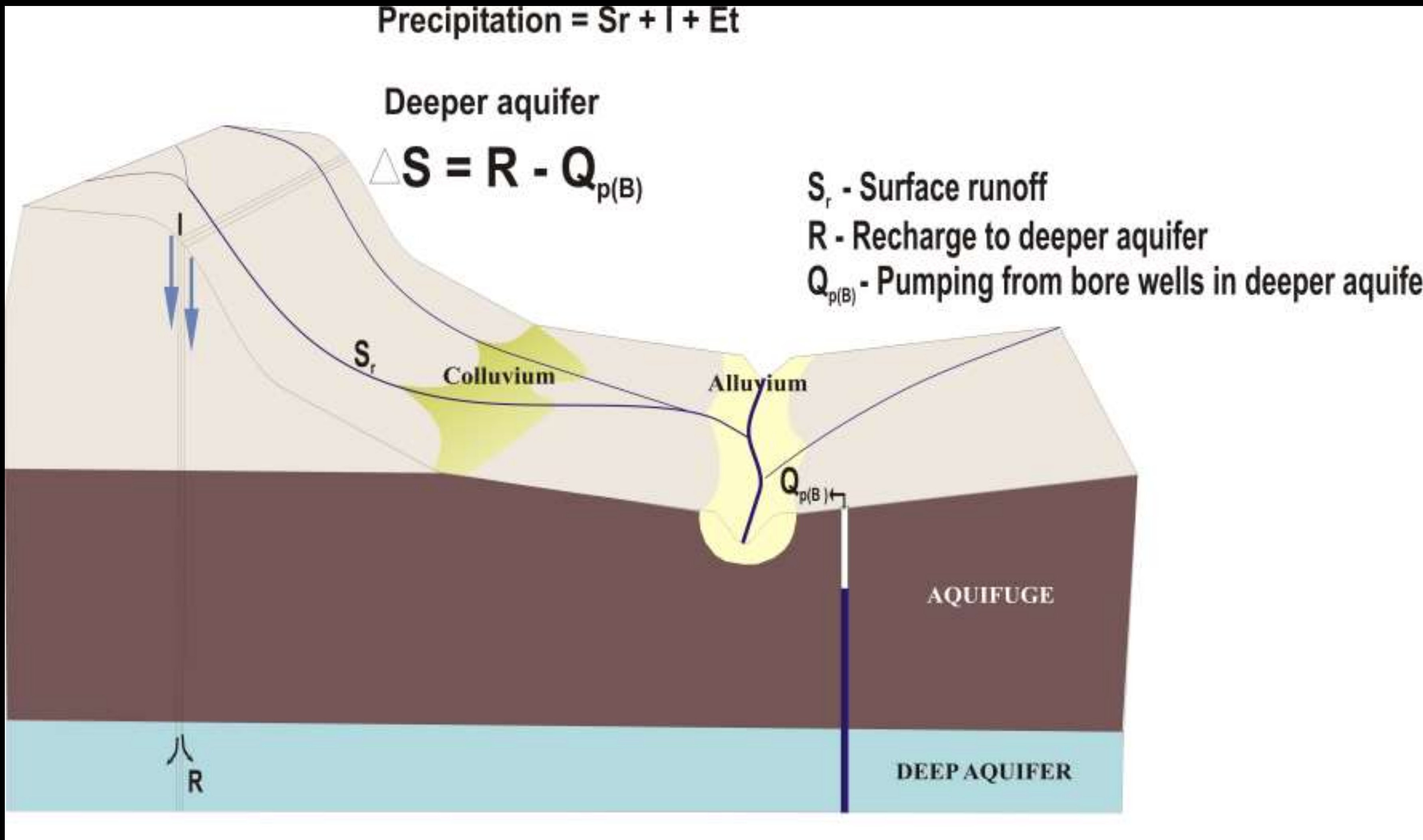

Ground surface
BEDROCK

The water balance for an aquifer (groundwater balance) may vary, depending upon the nature of a groundwater system, say in the watershed

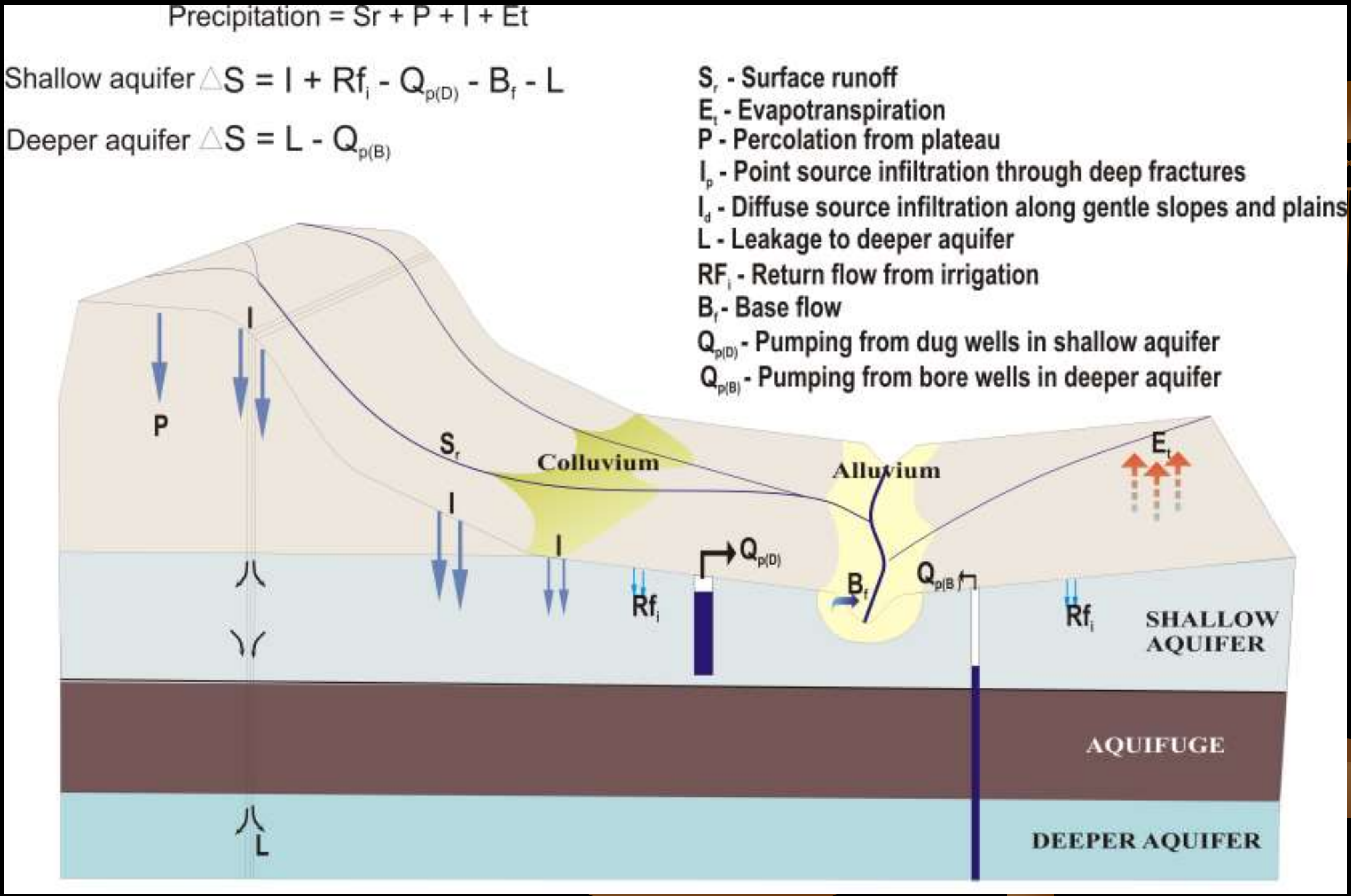
- Watershed with a deep aquifer
- Watershed has both shallow and deep aquifers
- Watershed has only shallow aquifer



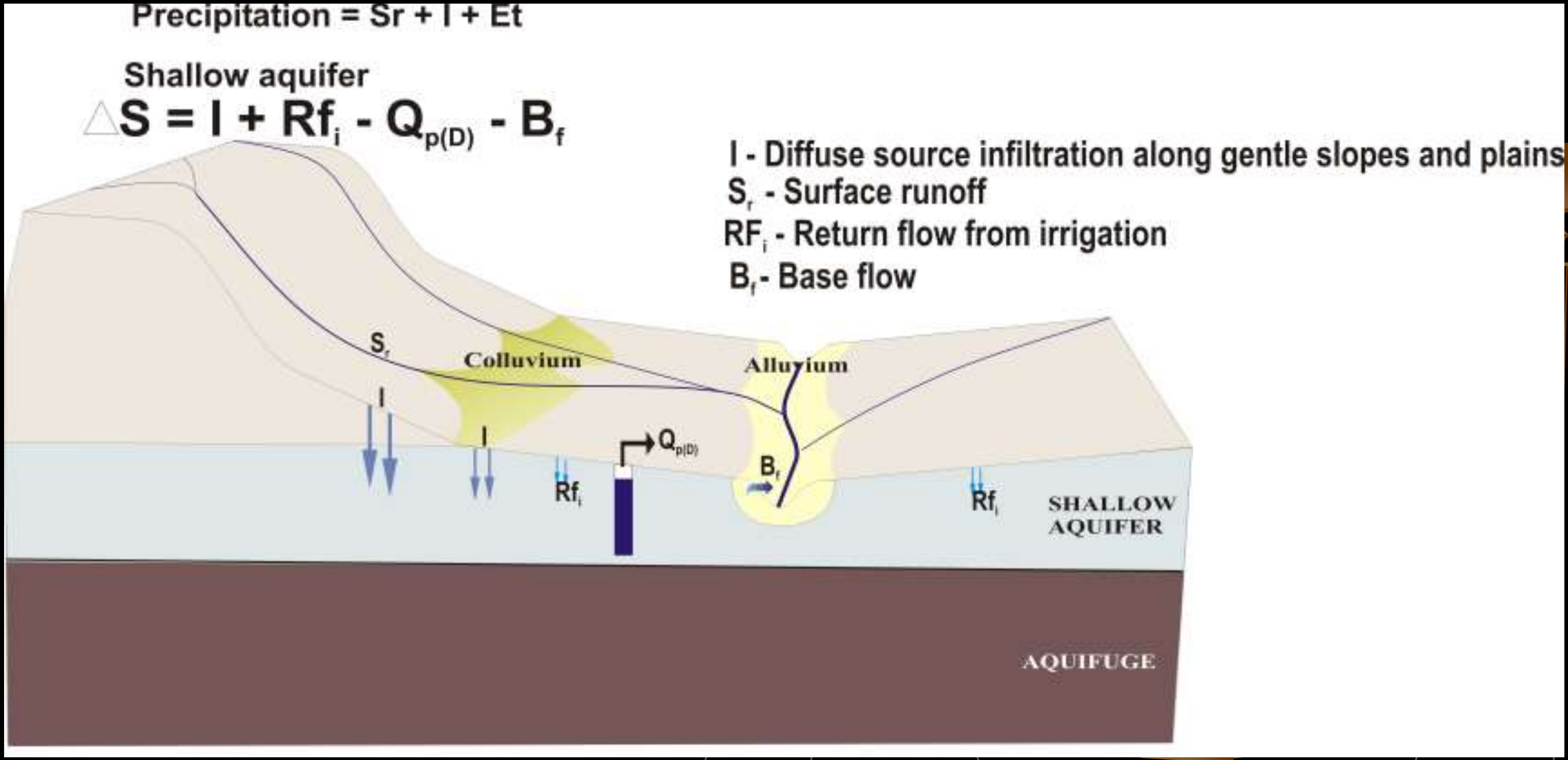
Deep aquifer only



Shallow and deep aquifers

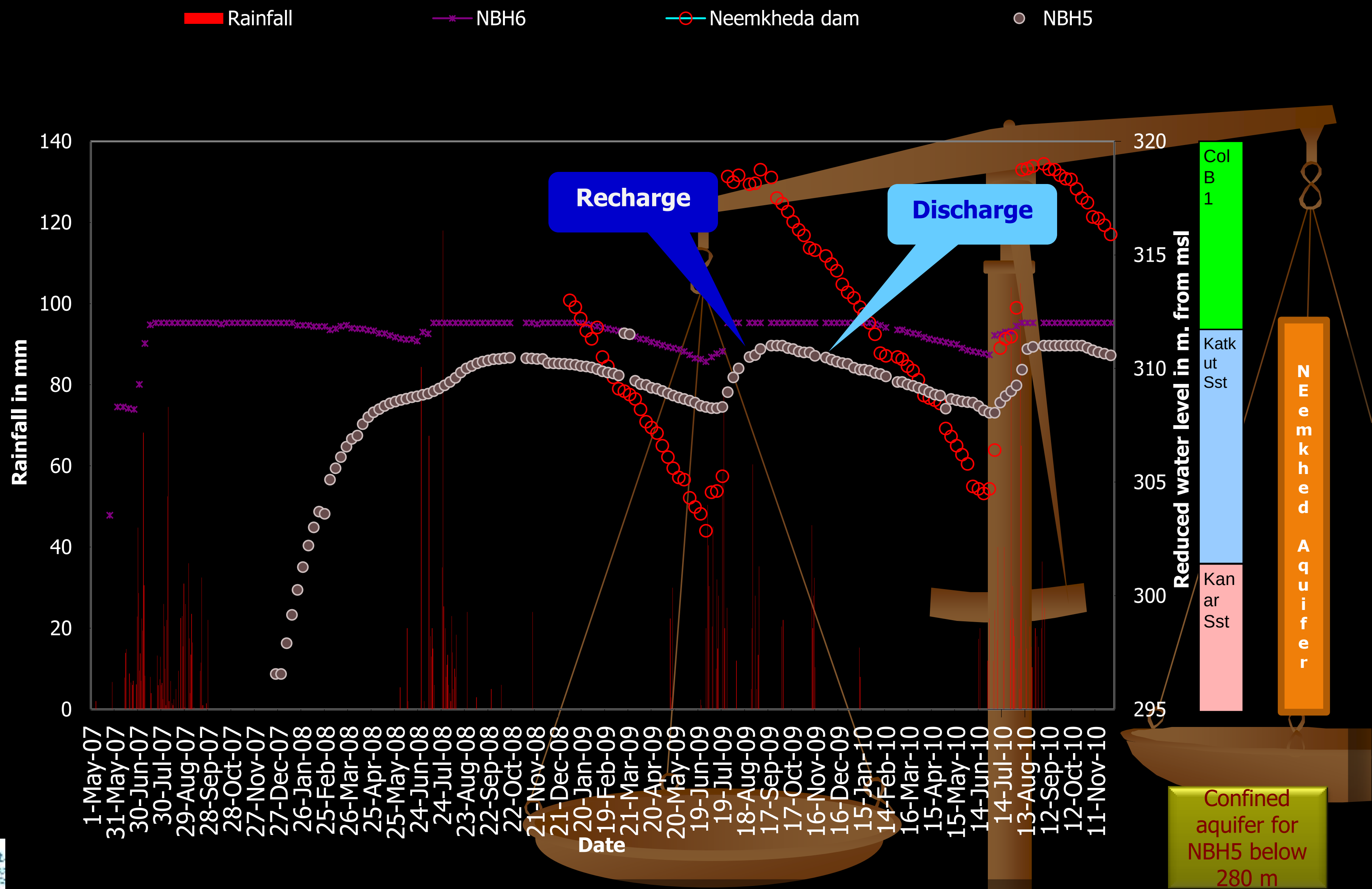


Components of a shallow aquifer



An understanding of a groundwater system or a set of aquifers in a watershed requires:

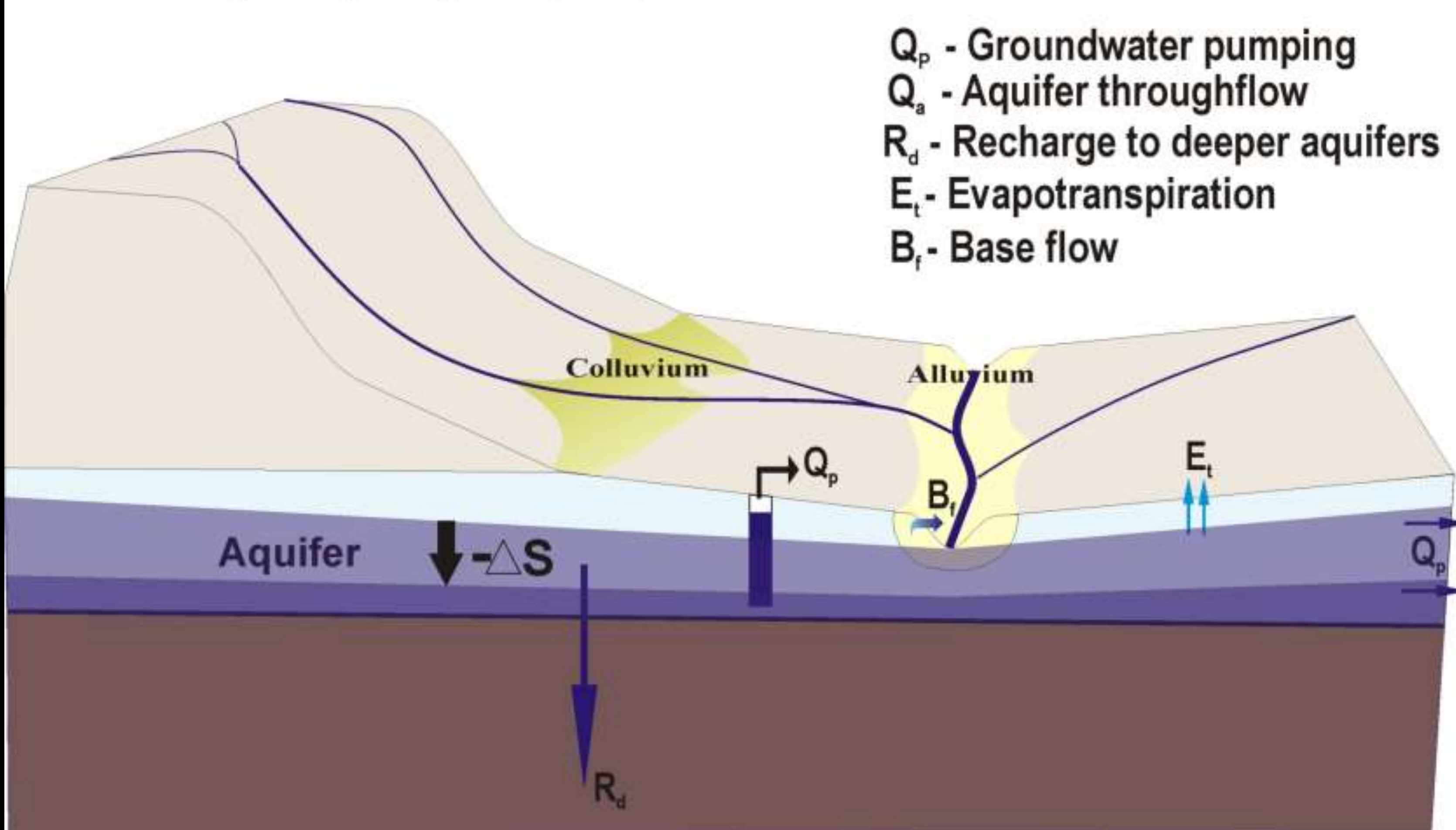
- Quantitative assessment of the INPUTS (Recharge) to and OUTPUTS (Discharge) from the aquifer.
- An idea about how and when these components work…



Rainfall
NBH6
Neemkheda dam
NBH5
Recharge
Discharge
Rainfall in mm
Reduced water level in m. from msl
Date
140
120
100
80
60
40
20
0
320
315
310
305
300
295
Col B 1
Katkut Sst
Kanar Sst
Neemkhed Aquifer
Confined aquifer for NBH5 below 280 m

Simplified groundwater balance equation

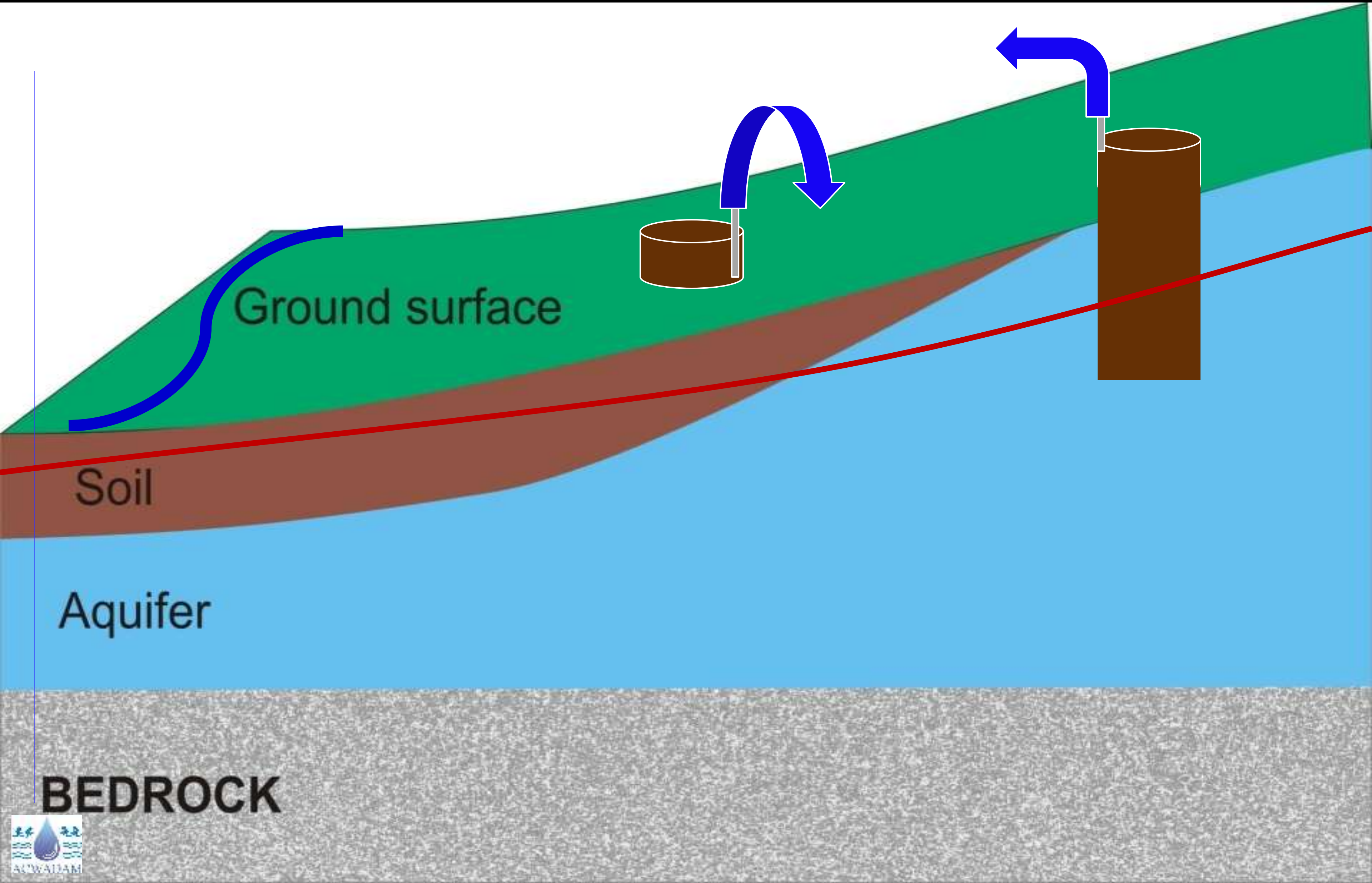
$$-\Delta S = Q_p + Q_a + R_d + E_t + B_f$$



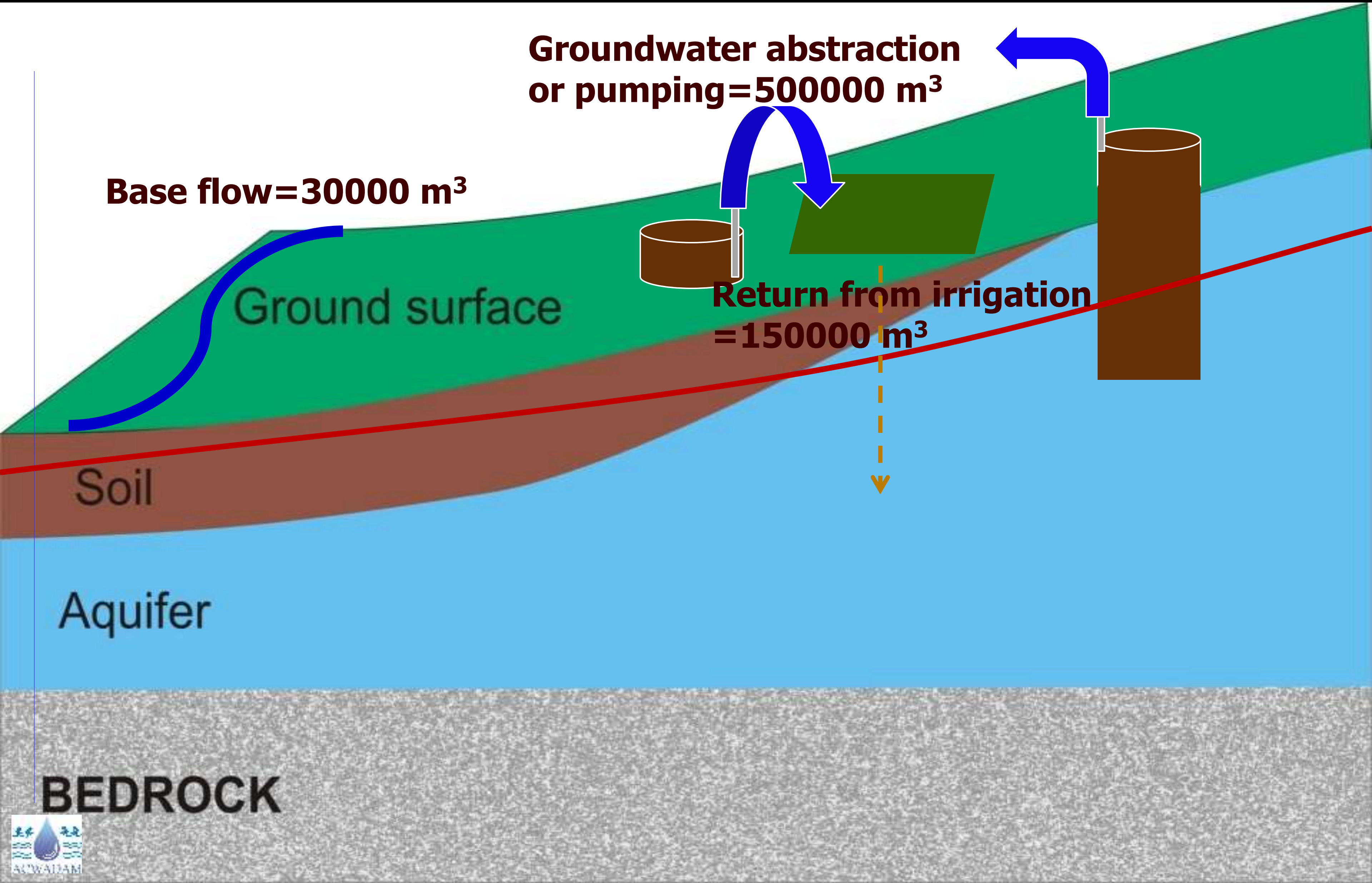
In many parts of India, where groundwater is pumped out in large quantities from shallow aquifers…and where water is limited in deeper aquifers

- Q_p- Groundwater pumping is the single largest component of groundwater discharge.
- Q_a- The intensive pumping of groundwater from the aquifer modifies the natural groundwater flow pattern and limits the quantity of water that flows out of the watershed as throughflow. *Throughflow Qa is negligible or zero*.
- B_f - Baseflow contributions to streams have reduced considerably because pumping from wells keeps the water table below the surface of the streams that tend to have little or no base flow.
- R_d- Recharge to deeper aquifers can be discounted since deeper aquifers are practically absent (in this example). In many areas water drawn from deeper aquifers is simply a case of mining very old water.
- E_t- Evapotranspiration from the water table is negligible since the water table is normally 3 m below the ground surface.

It is easier to measure "groundwater discharge"...



Major components of groundwater discharge and return flow

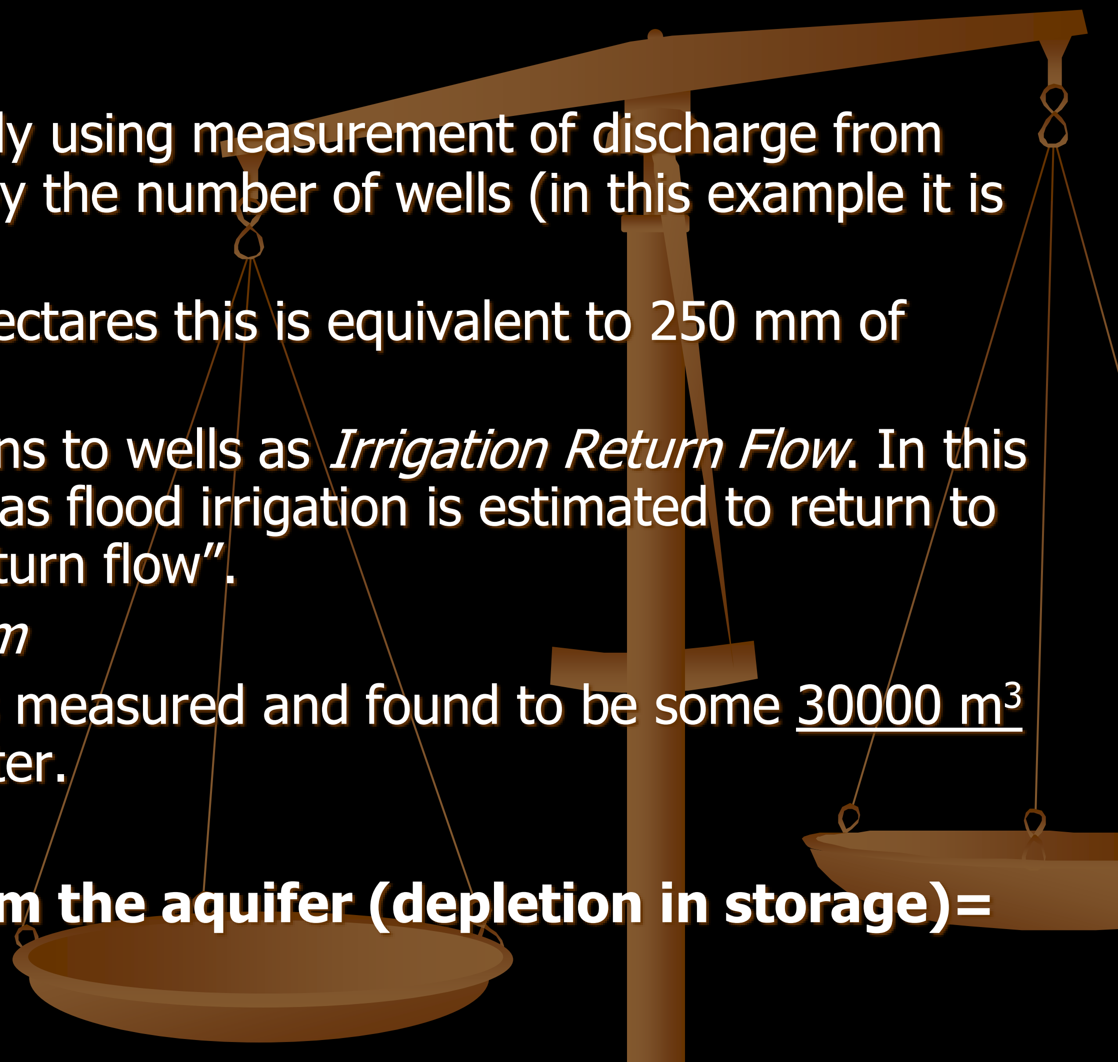


A simplified groundwater balance

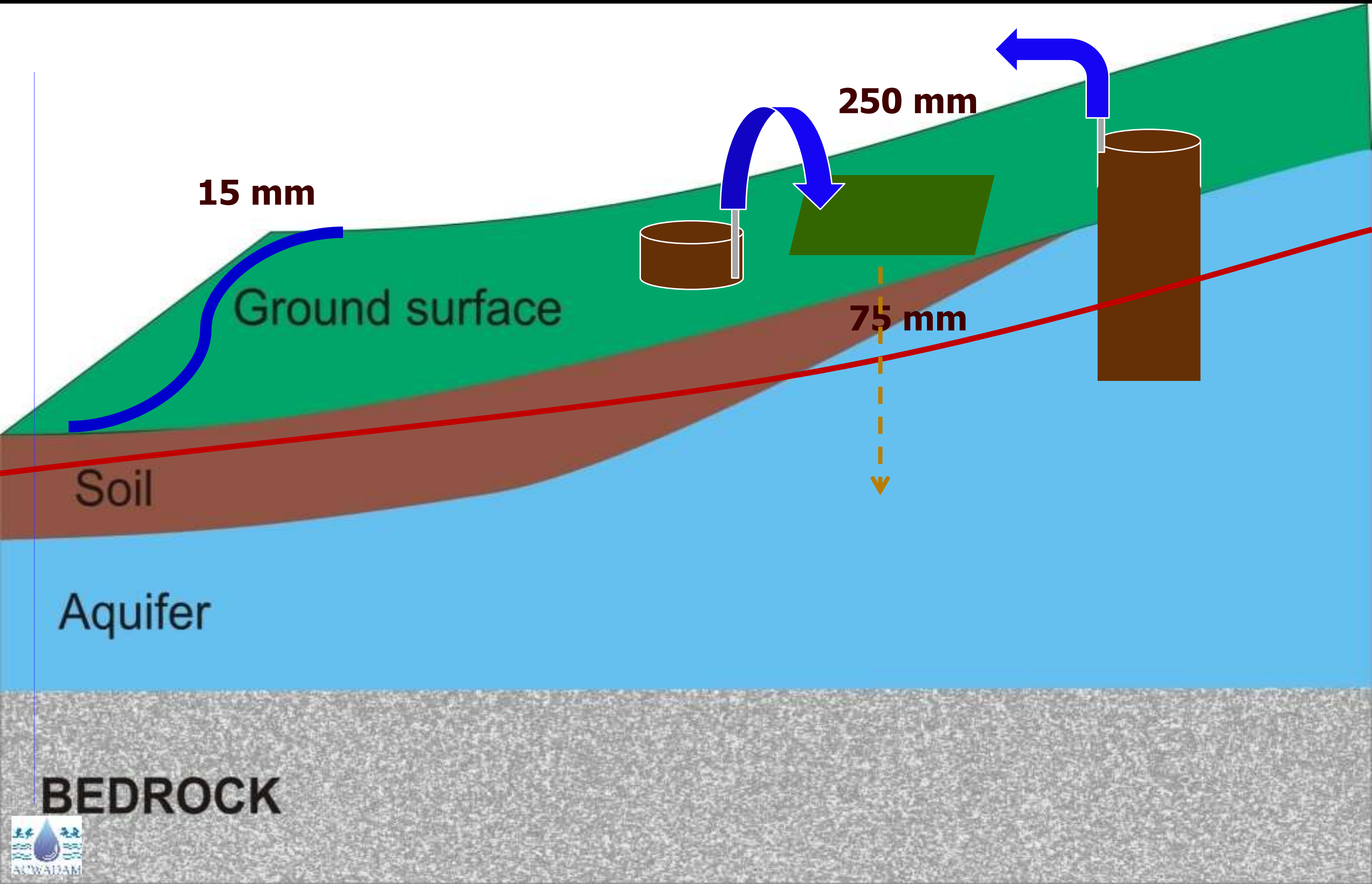
$\Delta s = Q_p + B_f$

- **Q_p** can be estimated directly using measurement of discharge from individual wells multiplied by the number of wells (in this example it is <u>5×10^5 m^3 per year</u>.
- For an area of about 200 hectares this is equivalent to 250 mm of water.
- Some irrigation water returns to wells as *Irrigation Return Flow*. In this area 30% of water applied as flood irrigation is estimated to return to the aquifer as "irrigation return flow".
- Hence, the *net Q_p= 175 mm*
- Other losses such as B_f was measured and found to be some <u>30000 m^3</u> equivalent to 15 mm of water.

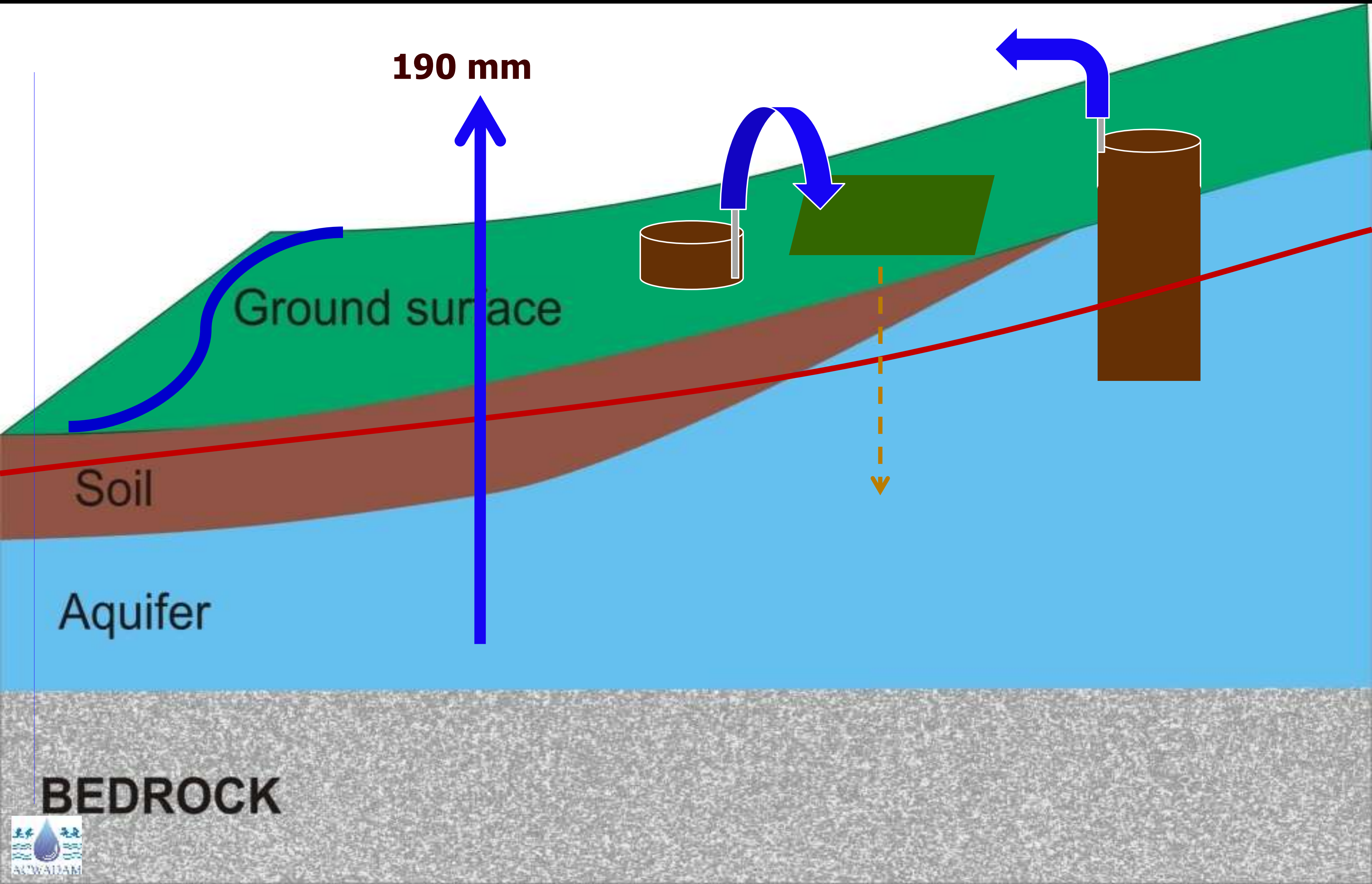
The net total discharge from the aquifer (depletion in storage)= 190 mm



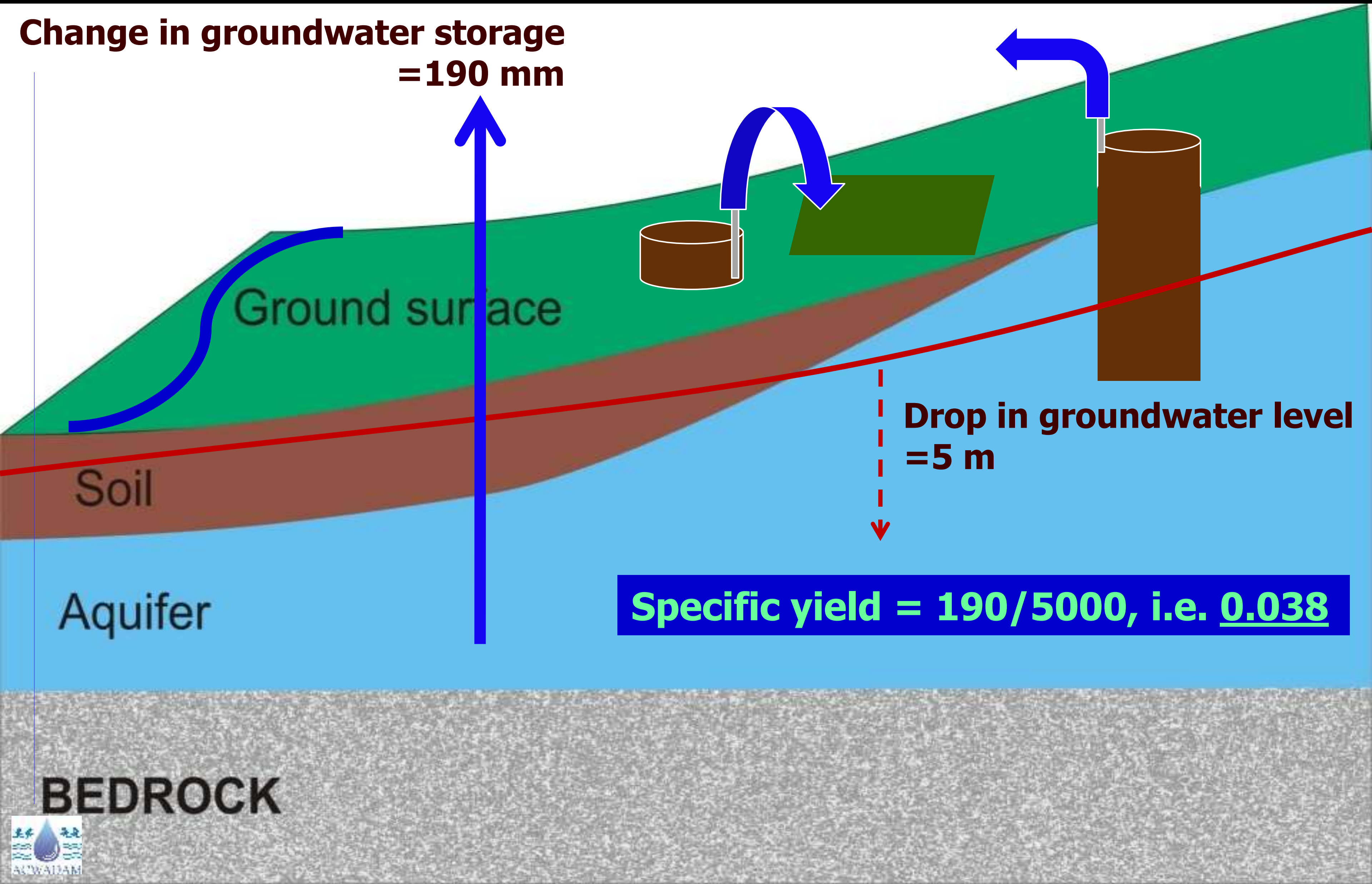
...conversion to mm for aquifer surface area of 200 mm



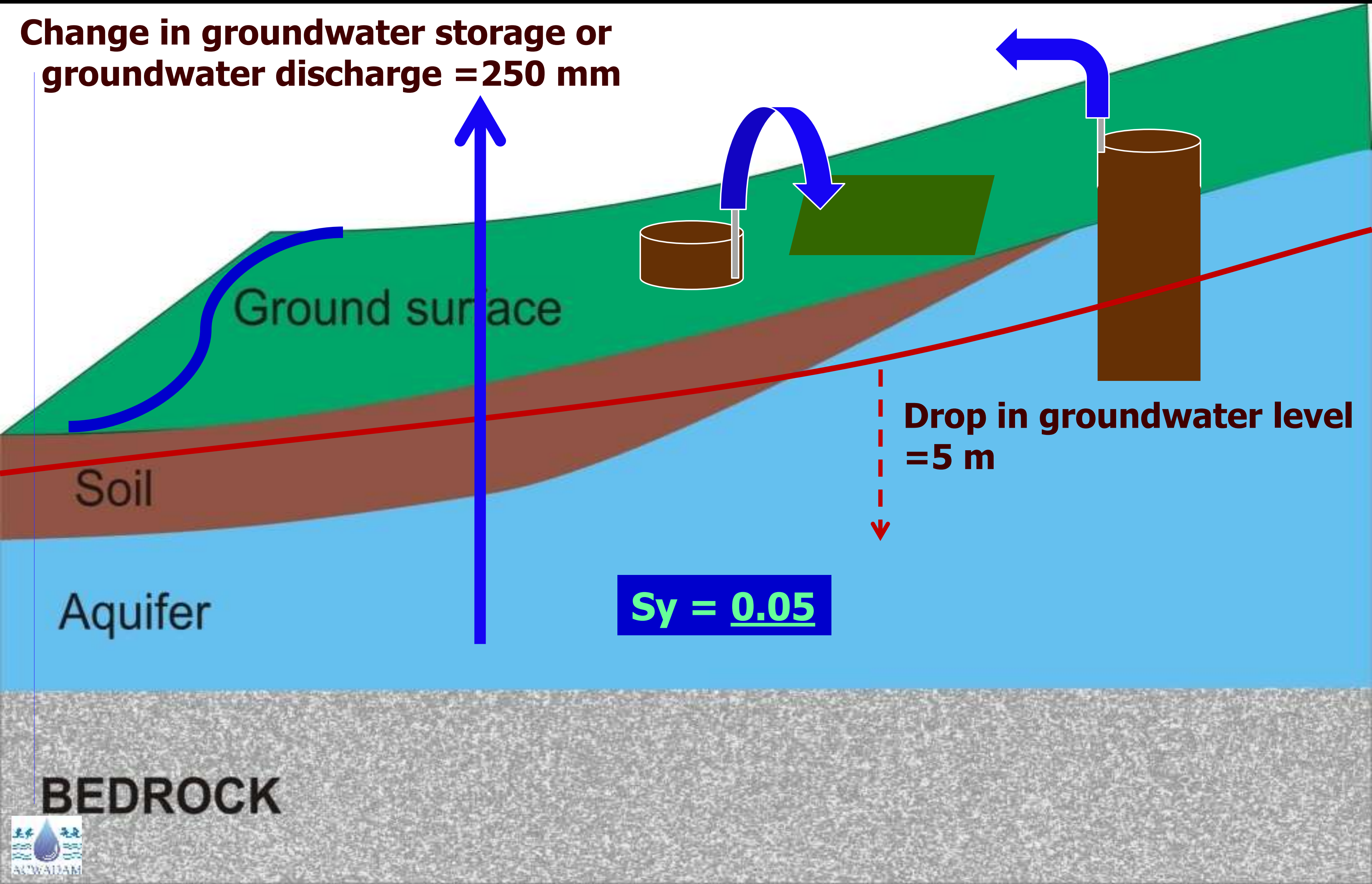
The processes in understanding the gw balance



Estimating an important parameter....



Estimating another important aspect...



Using the specific yield to develop the groundwater balance further…

GW discharge= annual wl fluctuation x specific yield of the aquifer

(the wl fluctuation= 5 m)

Two things are possible now:

1. The specific yield can be estimated using:

$Sy = \downarrow \Delta s / \Delta wl \downarrow$

In this case the specific yield= 190/5= 190mm/5000mm= 0.038 (3.8%)

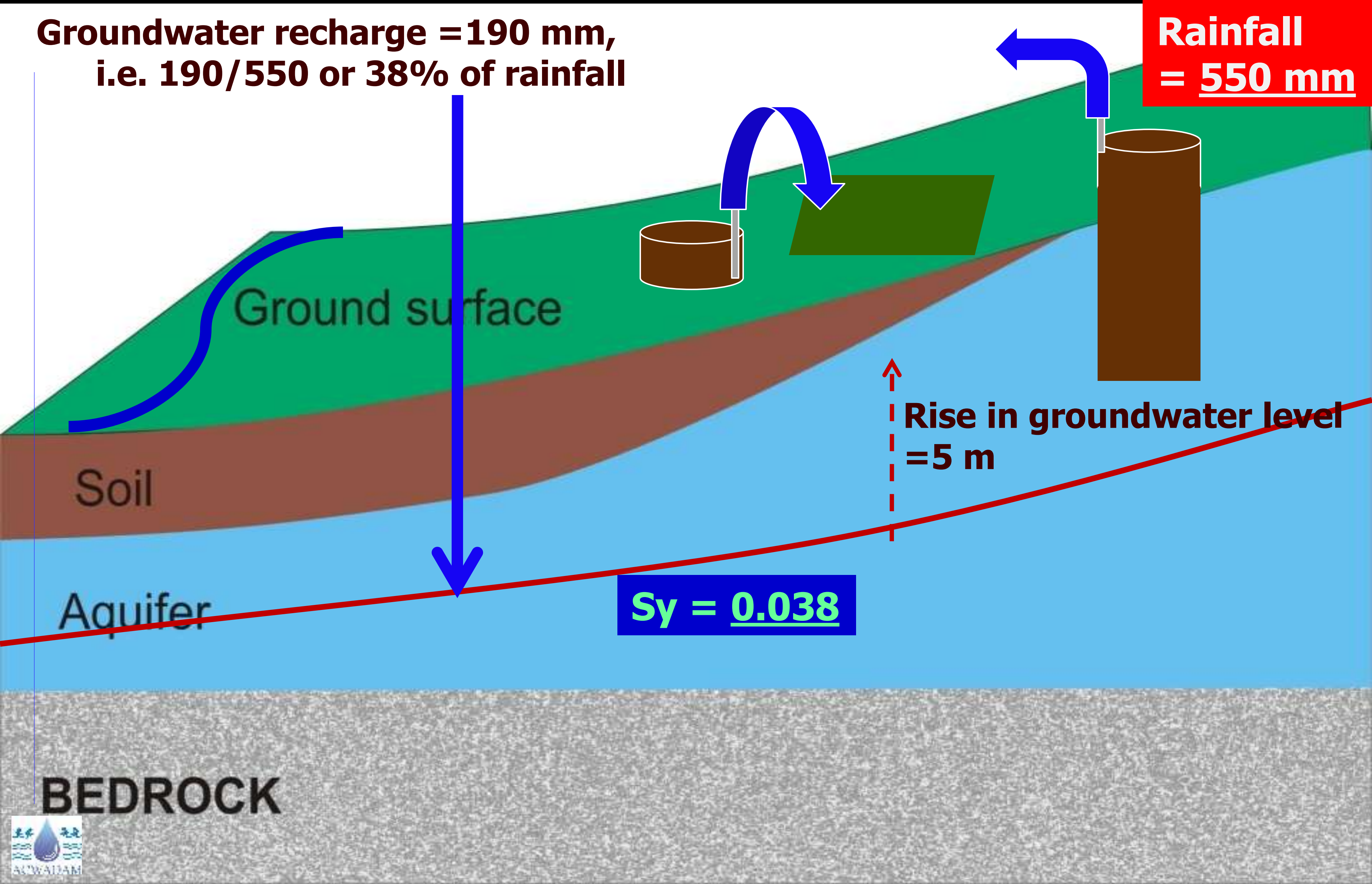
2. If the specific yield is known from PT data, either the groundwater discharge or loss from aquifer storage can be calculated:

$Sy = -\Delta s / \Delta wl$, *i.e.* $-\Delta s = Sy \times \Delta wl$

For instance, if the specific yield= 5% (0.05) and the water level drop= 5m

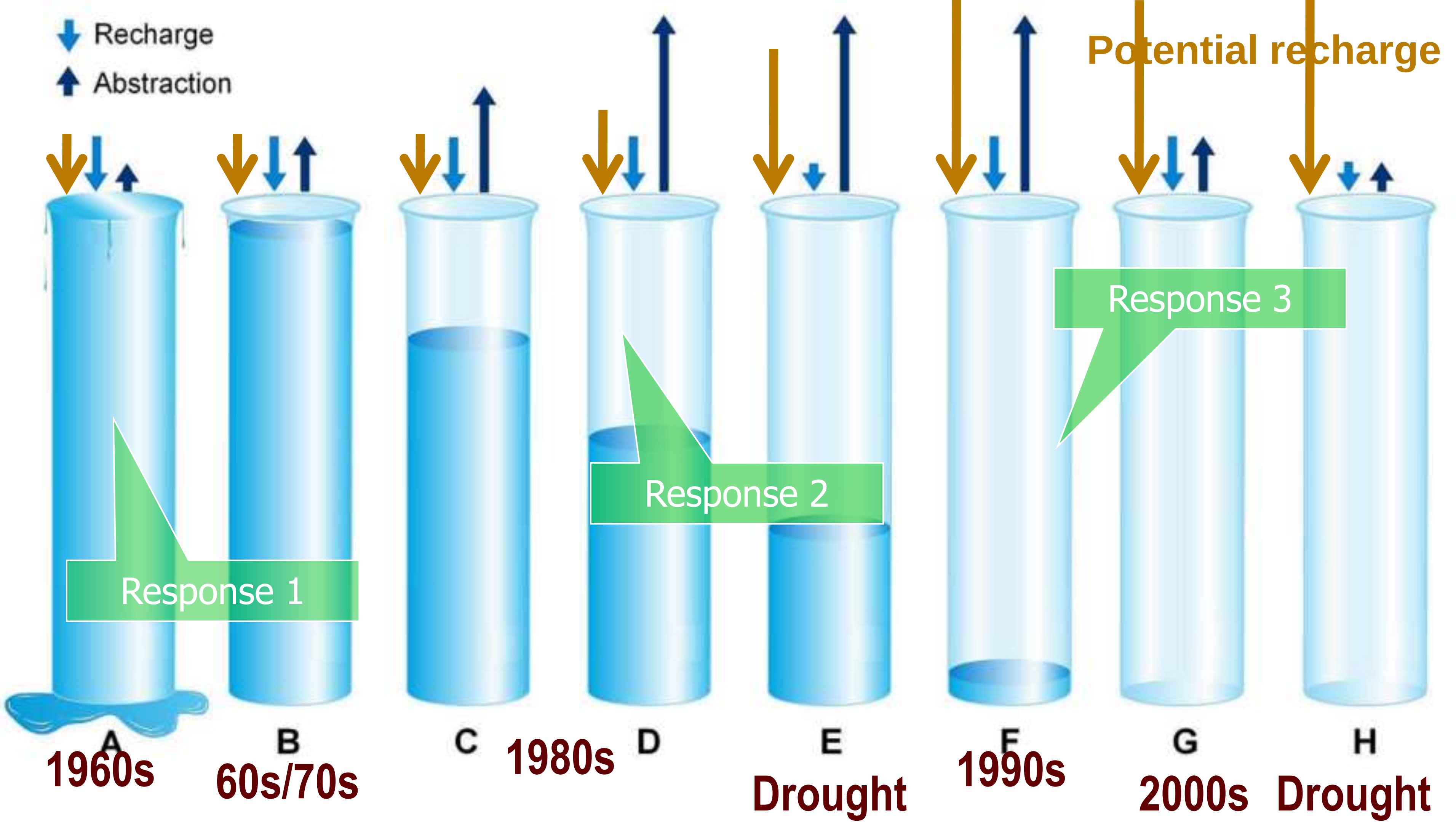
Then, groundwater discharge= 0.05 x 5000mm= 250mm

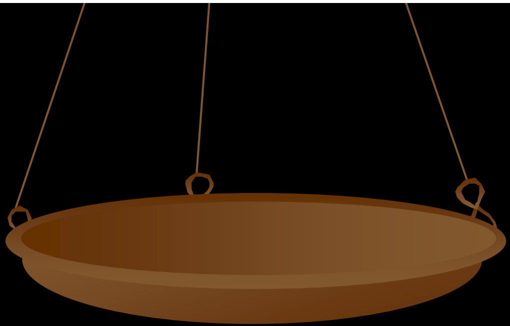
Recharge in proportion to rainfall...



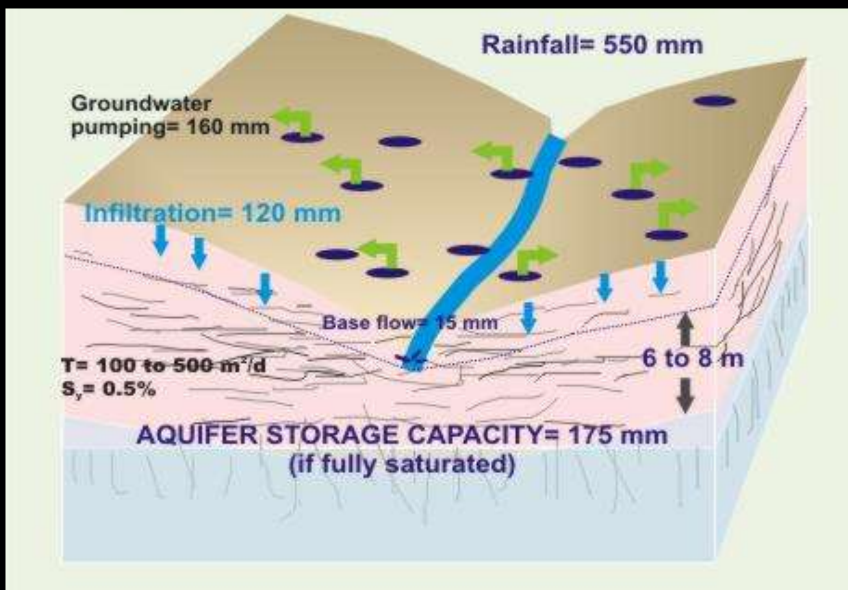
How do you equate recharge and discharge

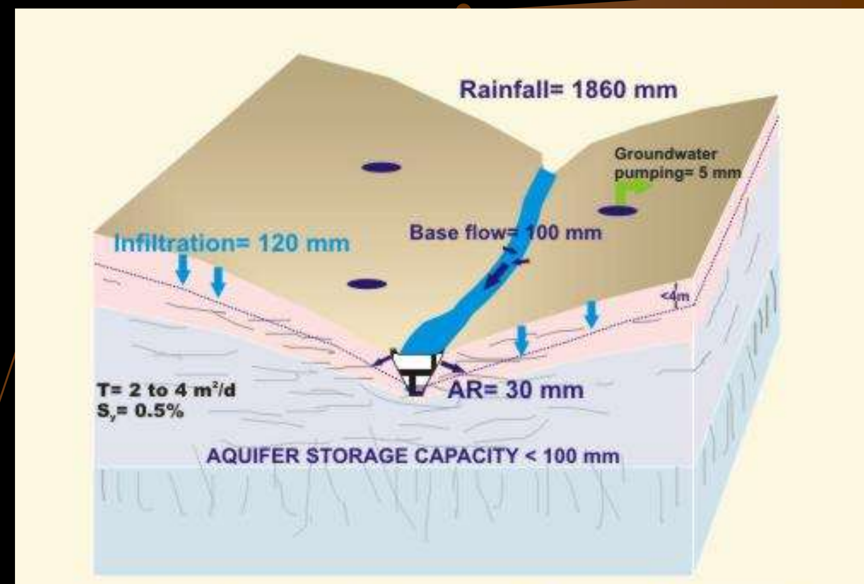
- In areas where the aquifer empties and fills up each year (a good balance between recharge and discharge), the value of net groundwater discharge is equal .
- In other words, the net discharge of 190 mm is the recharge required to fill up the aquifer to its original capacity.
- This means that if the rainfall is 550 mm annually, nearly 34%, of the rainfall is required to recharge the aquifer.
- This estimate of recharge can also be called POTENTIAL RECHARGE.


Recharge
Abstraction
Potential recharge
Response 1
Response 2
Response 3
A
B
C
D
E
F
G
H
1960s
60s/70s
1980s
Drought
1990s
2000s
Drought



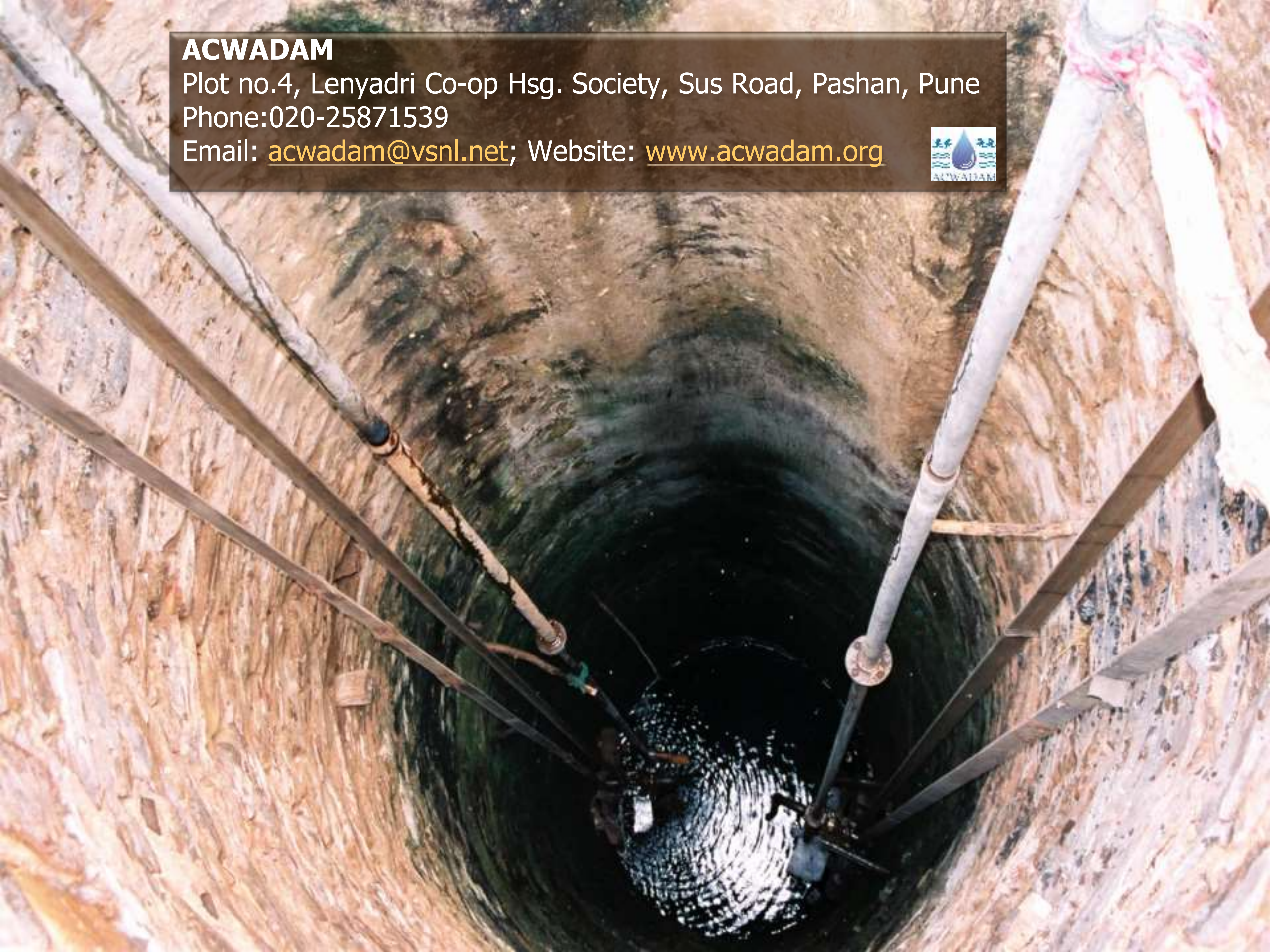
Recharge is addition to the existing aquifer storage and discharge is removal from aquifer storage





Depleted aquifer storage at the end of summer

Very little depletion in aquifer storage at the end of summer



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